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Medical PROGRESS

Detection and Management of Deep Vein Thrombosis

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The accuracy of diagnosis of deep venous thrombosis is significantly improved by combining clinical evaluation with other adjunctive methods, especially fibrinogen uptake tests, technetium scans, Doppler techniques and phlebography. Using these studies, early treatment with intravenous administration of heparin can be begun and in selected cases with long-term risks, warfarin is often useful. These same drugs, in different dosage schedules, may also be helpful as prophylaxis. With these methods of treatment, thrombectomy and caval interruption are required less often. If interruption of inferior vena cava flow becomes necessary, several new methods utilizing intracaval filters are proving to be very useful.

SEVITT AND GALLAGHER[1] examined an unselected group of fatally injured patients and found that in 60 percent deep vein thrombosis was present. They also noted deep venous thrombosis in more than 80 percent of elderly patients who died after having a fractured femur. Subsequently they showed that deep vein thrombosis occurred in 30 to 60 percent of patients after general surgical operations, and in up to 50 percent of patients in whom orthopedic operations on the lower extremities were being carried out. As has been emphasized by Skillman,[2] pulmonary embolism is a frequent occurrence after surgical operation, is one of the major causes of death after serious medical illnesses and is the greatest single cause of maternal deaths due to childbirth.

Pathophysiology

More than a hundred years ago Virchow[3] postulated that venous thrombosis occurred as a result of intimal damage, hypercoagulability and stasis of blood. Evarts[4,5] has recently suggested that two different types of thrombi occur: One is composed primarily of erythrocytes and fibrin, and characteristically is seen in areas of venous stasis. In the second type there is a white thrombus containing leukocytes, platelets and fibrin. The latter type of thrombus is found almost exclusively in association with rapid arterial flow, or in areas adjacent to injured vessel walls. Recent studies of venous thrombosis suggest that platelet activity may also trigger the formation of some venous thrombi, and that in some cases a small platelet nidus may precede activation of thrombosis.[5] Thrombus formation may therefore begin when platelets adhere to an altered intimal surface, or to exposed collagen in a damaged vessel wall. The subsequent activation of the intrinsic clotting mechanism produces the thrombus in a progressive reaction. There is persuasive evidence that this process may begin in valve cusps where there is stasis of blood, and therefore less effect of dilutional factors.[6] Changes in platelet adhesiveness occur during operation, after injury and in association with certain illnesses. In fact, results of

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studies of deep venous thrombosis have occasionally showed the presence of thrombi early during the surgical procedures.

Kakkar and his co-workers[7] have suggested that venous thrombosis usually starts in the tibial veins and the soleal sinuses, and then extends proximally into the popliteal, femoral and iliac veins. A dissenting view is taken by Mavor and his colleagues[8] who suggest that about two thirds of all pulmonary emboli arise from the ileo-femoral segment; they therefore consider these lesions to be primary. Kakkar and associates,[7] utilizing studies of deep venous thrombosis based on iodine-125 labeled fibrinogen scanning, showed that in approximately 35 percent of patients in whom localized increased radioactive counts persisted for more than 72 hours, there subsequently was extension of the clot into the popliteal and femoral veins. When this extension occurred in their study, the chance of a pulmonary embolus developing was approximately 40 percent. According to these workers, in those patients in whom clots were present only in the tibial or soleal veins, pulmonary embolism was very unlikely to occur. These data therefore strongly suggest that deep venous thrombosis may begin in the calf veins, but does not pose great danger to a patient until the clot extends into the femoral and iliac veins.

Diagnosis

The unreliability of clinical examination results in the detection of deep venous thrombosis is well known, but certain physical findings are helpful in establishing its presence. Edema of the ankle and leg, calf tenderness, tenderness in the popliteal and femoral areas, and a positive Homan's sign are considered characteristic of deep vein thrombosis. Findings on correlated studies suggest, however, that more than half of the patients with deep vein thrombosis diagnosed by other methods will be missed by clinical examination alone, and therefore adjunctive diagnostic techniques must be used.[2]

Ascending contrast phlebography is considered the most sensitive and complete of the tests and has been used to visualize the entire venous system of the lower extremity, iliac veins and vena cava. Other procedures used to diagnose venous thrombosis are compared with contrast phlebography as a standard, but because of the cost, risk and time, phlebography is not considered by most investigators to be a satisfactory screening technique. Many clinicians believe that phlebography should be reserved for patients in whom there are clinical signs and symptoms strongly suggestive of deep vein thrombosis, and in whom results of other less specific tests are equivocal. Phlebography is therefore particularly useful in specifically identifying deep vein thrombosis, excluding superficial phlebitis, cellulitis, hematomas and other conditions in which anticoagulation is not required.[9] It has been suggested that ascending phlebography also should be used before any operative procedure which incorporates interruption of the vena cava. In these cases contrast phlebography may establish the continued presence of potentially lethal venous thrombi, and may therefore offer compelling indications for operative intervention. Complications of ascending contrast phlebography are few, and are generally restricted to allergic reactions to the contrast media, localized phlebitis and hematoma at the site of injection, and, rarely, deep vein phlebitis. Pulmonary embolism occurring with ascending phlebography is extremely rare.

Numerous noninvasive techniques useful in the diagnosis of deep venous thrombosis have been proposed, including impedance plethysmography, phleborrheography, ultrasonic velocity flow detection, iodine-125 labeled fibrinogen scanning and radionuclide studies. Impedance plethysmography was described by Mullick and associates,[10] and is based on the principle that venous blood volume and the electrical impedance in the legs change with respiration if the venous system in the lower extremity is patent. When the test result is positive and compared with that from ascending contrast phlebography, the reliability appears to be approximately 90 percent, but when impedance plethysmography gives negative findings, the accuracy is reported to be only 50 percent. Recent modifications in carrying out the test have been advocated in which external compression of the leg is used instead of respiratory excursions, and this is reported to have increased the sensitivity and accuracy.

Cranley and his associates[11] developed a plethysmographic technique for the examination of thigh and calf volume changes in response to compression of the calf or foot. They have named this technique phleborrheography, and in their initial reports of 304 limbs there were only three false negatives. In addition, of 227 limbs for which findings were normal on phlebograms, only four false positives were discovered. These initial re-

ports strongly suggest that this innovative technique will be of great value in the detection of deep vein thrombosis.

The Doppler ultrasonic velocity flow detector has been useful in the detection of deep vein thrombosis. Strandness and Sumner[12] reported that this technique accurately predicted deep vein thrombosis in more than 93 percent of 53 patients in whom either venographic studies or operations subsequently were carried out in order to confirm the diagnosis. Sigel and his co-workers,[13] however, report on 8,500 examinations done in more than 5,000 patients. In results of 248 examinations with concurrent phlebography the Doppler survey agreed in approximately 75 percent of the patients with limbs containing venous thrombosis. With this extensive experience these authors concluded that the method was valuable, but could not detect mural clots, nor expose clots when only tributory veins were involved, and patent collateral veins were present. They also emphasized that error may arise because of improper positioning of the probe, emptying the veins by gravity or compression bandages. They concluded that the Doppler velocity flow meter was particularly useful in detecting complete thrombosis involving the femoral and the iliac veins, especially when recent. This technique therefore has certain limitations and can not be reliably employed as a solitary method of examination.

Flanc, Kakkar and their associates[14] pioneered in the technique of utilizing fibrinogen tagged with iodine-125 in the diagnosis of deep vein thrombosis. The test requires that the radioactive fibrinogen be incorporated into newly forming thrombi; then the activity is detected by scanning the leg and thigh with a portable scintillation counter. This has proven to be an extremely useful and valuable test in the detection of deep vein thrombosis, but is not completely reliable in patients with established clots because it depends on incorporation of the labeled fibrinogen into the thrombus. It may be useful for the detection of iliac and pelvic vein thrombosis, but cannot be used immediately adjacent to areas of recent surgical wounds about the hip because of pooling and hematomas near the operative incision. It is the single most sensitive and useful noninvasive test in the diagnosis of deep venous thrombosis. It has been widely used in Europe but because of limited access to hepatitis-free fibrinogen it has not been used as frequently in the United States.

Pollak and his associates[15] studied deep vein thrombosis in a group of patients utilizing labeled fibrinogen, and venous imaging with technetium-99m (^{99m}Tc). Microaggregates of albumin incorporating technetium-99 are prepared to form particles 10 to 50 microns in size, and the solution subsequently injected into dorsal veins of the foot. Isotope distribution in the legs and pelvis is then detected by scintillation counters and photographed. In these same patients autologous fibrinogen is secured, and labeled with iodine-125, and injected into an antebrachial vein. Isotope localization is then detected with scintillation counters. These investigators utilized both of these tests in a series of 89 patients and concluded that an abnormal finding on technetium scan is accurate in more than 90 percent of cases, and 80 percent reliable in separating patients with venous disease from those who do not have deep vein thrombosis. They emphasized that false positives occur because any area of endothelial damage may trap aggregates, and thereby localize the isotope. They stated that the fibrinogen uptake test is considered to be 100 percent sensitive in differentiating active recent thrombosis from long-standing venous obstruction. They therefore concluded that use of a combination of these two tests offers reliable evidence as to the presence of deep vein thrombosis, and may obviate the necessity of carrying out contrast phlebography.

The proliferation of various tests proposed to assist in the diagnosis of deep vein thrombosis underscores the difficulty of accurate identification of patients with this disease. Fibrinogen uptake tests appear to be the most sensitive, and are considered by many workers to be extremely reliable in the detection even of small vein thrombosis. Plethysmographic techniques developed by Cranley and his associates[11] promise to be of great value, and perhaps will be more useful than impedance plethysmography. It is clear that the clinical evaluation is materially improved when combined with radionuclide studies, Doppler ultrasonic examinations, and especially if fibrinogen uptake tests are also used. All of these tests are compared with ascending contrast phlebography, and it is apparent that despite its invasive nature, use of phlebography may be required to resolve differences in interpretation of the various other tests.

Prevention of Deep Vein Thrombosis

Linton, Ochsner and others[9] for a number of years have stressed the function of the "peripheral

heart" in maintaining normal venous return and avoiding stasis. They have emphasized the importance of the soleal pump, elevation of the lower extremities, the maintenance of normal blood volume and plasma composition in reducing the incidence of stasis and venous thrombosis. Flanc and his co-workers[14] reported the results of an intensive program of prophylactic physical measures instituted in a group of 67 patients who were preoperatively instructed in active leg exercises. The subsequent diagnosis of deep vein thrombosis was based on a positive labeled fibrinogen uptake test. Of those elderly patients in whom major operations were carried out the incidence of deep vein thrombosis was 61 percent in the control group, but only 24 percent in the test group—a significant difference.

Tsapogas and his associates,[16] utilizing labeled fibrinogen scans, have reported a reduction in deep venous thrombosis by active exercises. In contrast, in a randomized study reported by Rosengarten and co-workers,[17] compression stockings in a group of 50 patients in whom elective general surgical procedures were being done could not be shown to be beneficial in preventing deep vein thrombosis.

Intermittent rhythmic compression of the legs produced by external pneumatic devices has been suggested as a useful substitute for the "soleal pump."[4] Although several early reports from these studies suggest that such procedures may be useful in preventing stasis, and perhaps deep venous thrombosis, there has not been sufficient experience to determine the true effects of the technique. These studies have generally been related to personal experience and do not reflect controlled scientific data, but it is reasonable to assume from the frequency of these reports and from the experience of many investigators that prevention of venous stasis is an important concept of prophylaxis against deep venous thrombosis.

Prophylactic Drug Therapy

Several drugs are known to prevent thromboembolism in high risk patients, and as Salzman[9] has emphasized, the evidence is most convincing for the case of warfarin and other oral anticoagulants. He and his associates reported that clinically detectable thromboembolic complications can be significantly reduced in patients with fracture of the hip if prophylactic warfarin is administered. In a prospective randomized study of thromboembolic disease following total hip replacement in 237 patients, Harris[18] reported that warfarin sodium and dextran 40 were equally effective in preventing fatal emboli. There were no statistically significant differences between the two agents. In this high-risk group of patients, clinically detectable thromboembolic disease occurred in 10 percent.

In contrast, Ritter and Hamilton[19] examined the effectiveness of warfarin and low dose heparin as thromboembolism prophylaxis in patients undergoing total hip replacement. In all, 380 consecutive cases of total hip replacement orthoplasties were divided into four groups for purposes of treatment and analysis. All patients were treated with mild elevation of the legs and elastic stockings, and they were encouraged to use their calf and thigh muscles. The diagnosis of venous thrombosis was made by clinical criteria, using the classic signs of calf tenderness, warmth, edema, Homan's sign and fever. One group of patients received sodium warfarin on the night of surgical operation, and beginning on the second day doses were given each day in an effort to maintain the prothrombin time at twice the control value. Group two received low-dose heparin as recommended by Kakkar and his colleagues, 5,000 units 2 hours before operation and every 12 hours postoperatively. Group three received low-dose heparin administered eight hours preoperatively, and group four had, in addition to the low-dose heparin, hydrocortisone given three times per day. The lowest incidence of thromboembolic phenomena occurred in patients receiving warfarin. The average blood replacement was highest in those patients given heparin two hours before operation. The study therefore suggests that oral administration of anticoagulants may be more effective in the prevention of thromboembolism in high-risk patients.

In a study of 514 patients receiving low molecular weight dextran, Evarts[4] stated that the expected incidence of deep venous thrombosis was reduced to 4.3 percent. In only five of the 514 patients did nonfatal pulmonary emboli develop, an incidence of 1 percent. Evarts therefore suggested that dextran 40 is the agent of choice in these patients, but other investigators take a dissenting view. Skillman and Salzman have emphasized that the complications and expense associated with use of dextran may detract somewhat from its usefulness. Salzman further stated that "dextran produces allergic reactions frequently, anaphylactic reactions occasionally, and renal

failure rarely." From these data, however, it is apparent that the prophylactic administration of warfarin sodium or dextran, or both, may be useful in the prevention of deep venous thrombosis in high-risk patients, although certain undesirable side effects may be encountered.

Kakkar, in an initial report concerning more than 4,000 patients admitted to a prospective control study, suggested that low-dose heparin is the most effective prophylactic agent.[2] In these patients, 5,000 units of aqueous heparin was administered subcutaneously two hours before and immediately after operation, and at eight hour intervals thereafter. The beneficial effects seem to be the result of the potentiation of factor Xa inhibitor, a naturally occurring anticlotting factor. According to these workers the regimen is useful in patients in whom general surgical operations are being carried out, but is not as effective in high-risk patients in whom orthopedic procedures have been done. The results reported in approximately 4,000 of the 20,000 patients in this prospective study are encouraging: only one case of pulmonary embolism in the heparin-treated group has been reported as compared with 12 in the control group.

In a coded, prospective study by Covey, Sherman and Baue,[20] low-dose heparin was found not to be as effective as other means in preventing thromboembolic phenomena. These workers studied the cases of 105 patients randomly divided into control and treated groups, utilizing low-dose heparin as described by Kakkar. Deep venous thrombosis was detected by daily fibrinogen scanning, and then confirmed by ascending contrast phlebography. Both groups were comparable by age, sex, type of operation and incidence of previous thromboembolism, and also by presence of myocardial or cerebral vascular disease, or both. In this study blood loss was not increased in the treated group. The incidence of deep venous thrombosis was 8.6 percent for the total group, 7.5 percent in the heparin-treated group and 9.6 percent in the control group. There was one pulmonary embolus seen on scan in one of the patients in the control group. The authors concluded that this study showed no increased hemorrhage in heparin-treated patients, but neither did it show a beneficial effect of heparin administration in preventing deep vein thrombosis.

Salzman and his associates[18] reported on the prophylactic effect of dipyridamole, aspirin and dextran in patients in whom hip orthoplasty was done. Dipyridamole was eliminated from the study early because of the 34 patients being treated with this drug, thromboembolic complications developed in 26. The incidence of thromboembolism in the group treated with aspirin and dextran was approximately the same as in those patients treated with warfarin, and the authors concluded that in all the patients significant protection was conferred by administration of these drugs. The report by the National Research Council in Britain, covering 303 patients in whom elective operations were done, gives findings at variance with these data in that no protective effect of aspirin administration could be shown, utilizing labeled fibrinogen scans to detect deep venous thrombosis.[2] Because of such discrepancies, use of primdopyrimidine compounds and administration of the nonsteroidal antiinflammatory agents such as aspirin cannot at present be recommended as effective prophylactic antithrombotic measures under currently employed protocols.

These conflicting reports as to the effectiveness of the prophylactic measures are difficult to reconcile, but appear to be the result of varying methods of study, different dosage schedules, variations in types of drugs used, nonstandardized methods of detecting deep vein thrombosis and inadequately controlled data. From these studies, however, certain conclusions seem warranted. It appears that in older patients, in patients with a history of deep venous thrombosis or pulmonary embolism, or in patients in whom the presence of varicose veins, obesity or malignancy is found deep venous thrombosis is likely to develop. In these high-risk patients prophylactic low-dose subcutaneous heparin, or warfarin sodium may be useful. When contraindications to prophylactic anticoagulation are present, the fibrinogen scanning technique is useful in the early detection and treatment of deep venous thrombosis.

Superficial Phlebitis

In patients with phlebitis confined to the superficial venous system, anticoagulant therapy rarely will be required. Elevation, rest and elastic compression will usually be successful in the management of these problems. In some patients superficial phlebitis extends above the knee, and it has been suggested by Cranley and others[11] that ligation of the saphenous vein at its entrance into the common femoral vein is effective in treating these patients. This procedure often produces

early resolution of the processes, and may prevent thrombotic extension of the deep venous system. It is carried out under local anesthesia and usually reduces pain and morbidity within the first 48 hours after operation, and allows an early discharge from hospital.

Deep Vein Thrombosis

Deep vein thrombosis is best treated by venous infusion of heparin. In the regimen described by Dale,[9] aqueous heparin—5,000 international units—initially is administered by intravenous push. If a continuous intravenous infusion of heparin solution is then administered, a patient of average weight would receive approximately 12,500 units of heparin in 500 ml of 5 percent dextrose solution every eight hours. A continuous infusion pump is desirable, and levels of heparin activity are usually monitored by measuring activated whole blood partial thromboplastin time at least once a day during therapy. Heparin sensitivity increases as administration of the drug is continued and the thrombotic process resolves, and it is often necessary to subsequently readjust the dose to lower levels. Most clinicians maintain an activated whole blood partial thromboplastin time of approximately twice the control level.

Salzman and Hume and others[9] propose that in a patient with deep venous thrombosis, warfarin sodium be given concomitantly with heparin administration, and that the disorder slowly be brought under control with the use of the orally given anticoagulant. The usual practice is to give both agents for ten days, and then subsequently the orally administered medication is continued for several months if predisposing conditions leading to the deep venous thrombosis cannot be eliminated. Initially the prothrombin time is checked every day during the first week, and subsequently two or three times a week. A dissenting view is taken by Dale,[9] however, who does not use orally given anticoagulants concomitantly with the heparin infusion, nor does he use warfarin in patients who cannot be followed very closely because of the risk of dangerous bleeding. He also describes seeing acute exacerbations of venous thrombosis, and even fresh clots in patients in whom adequate anticoagulation is achieved using warfarin.

Following a major surgical procedure, anticoagulants must be given judiciously, and most workers suggest that they can safely be started within 6 to 12 hours after the operation is concluded. This may not be true in patients in whom orthopedic procedures or radical prostatectomies have been done, or in patients in whom there is danger of retinal or intracranial hemorrhage. Most clinicians combine anticoagulant therapy with elevation, and in some instances elastic stockings when venous abnormalities are present. Ambulation is usually begun as soon as symptoms permit because it is desirable to return the venous circulation to normal as soon as possible, while the patient is under the protection of intravenously given heparin. Once the swelling is resolved and the pain permits, full ambulation is therefore begun and when leg swelling has decreased sufficiently, measurements for a custom-fitted elastic stocking are taken.

Thrombolytic Agents

Streptokinase and urokinase were utilized in a cooperative study in the evaluation and treatment of pulmonary embolism, and have been shown to hasten the lysis of clots in patients with established pulmonary emboli.[2] Although the morbidity and mortality in this group of patients were not significantly changed, use of these thrombolytic agents may shorten the course of venous occlusion, and perhaps reduce postphlebitic phenomena. Silver[21] has shown that if heparin is given in sufficiently large amounts clotting is inhibited and thrombolysis is augmented. Accelerated lysis induced by these agents may therefore be important adjuncts in managing patients with deep venous thrombosis and massive pulmonary embolism, but they cannot be administered in the immediate postoperative period to patients after serious trauma has occurred, or after extensive surgical procedures. These agents may be useful in certain cases in which massive thrombosis is present if the risks are not extended by a recent surgical procedure.

Operative Procedures

Iliofemoral venous thrombectomy as originally described by Mahorner, Haller and others is useful in the treatment of patients with phlegmasia serulea dolens.[22] Of patients in whom massive iliofemoral venous outflow block has occurred, amputation is required in almost a third, and without treatment approximately one in four will die. It has been shown in other patients with less serious iliofemoral venous thrombosis that elevation, rest and intravenous heparin administration are quite effective, and surgical operation is

often not required. When there are contraindications to the administration of anticoagulants or there is threatened tissue loss, venous thrombectomy may be very useful—and often produces a dramatic response. Some surgeons suggest that vena cava interruption should accompany this operation, but others believe that if complete thrombectomy is done early in the disease, thromboembolic phenomena are very uncommon.

Contrast phlebograms, made at varying intervals after iliofemoral venous thrombectomy, have shown that in many people the operation has failed and the segment of vein operated upon has reclotted.[23] Additionally, the proposed aim of preserving valvular function by early operation has not been consistently accomplished. In fact, late phlebographic studies show that the incidence of postphlebitic problems is quite similar in patients treated with heparin and in those treated with operation. For these reasons most surgeons limit iliofemoral venous thrombectomy to patients who are threatened with loss of life or limb.

Interruption of Inferior Vena Cava

Silver[21] reports a 3 percent incidence of recurrence of pulmonary emboli in patients treated with a continuous infusion of intravenous heparin, a recurrence rate comparing favorably with those results obtained with caval interruption. Most clinicians now believe that caval interruption should be undertaken only in those patients in whom heparin therapy has failed, those in whom anticoagulation cannot be done because of concomitant illnesses such as bleeding ulcers, patients in whom there have been recent operations upon the brain or retina or people in whom orthopedic operations have been carried out recently. A documented recurrence of pulmonary embolization in patients adequately treated with intravenous heparin is generally considered by most clinicians to be an indication for caval interruption. The recurrence of small emboli under adequate therapy is also considered an indication for caval ligation. Septic emboli are now usually treated by a combination of heparin and appropriate antibiotics, because ligation procedures have failed to completely trap these very small emboli which are able to traverse collaterals and eventually reach the pulmonary circulation.

Inferior vena caval ligation has been the most commonly employed method of caval interruption, but numerous methods of partial interruption have been advocated as being effective, and are said to be accompanied by a lower incidence of venous thrombosis. These methods of partial interruption include narrowing the cava with Teflon® clips, compartmentalization or plication with sutures, or construction of a filtering grid across the lumen of the cava. Recently innovative intracaval techniques have been introduced in the form of fenestrated catheters, balloon catheters, metal cones and an umbrella that has been extensively employed over the past few years.[2,22] The Mobin-Uddin[24] umbrella is a fenestrated or solid Silastic umbrella which under local anesthesia may be inserted into the infrarenal cava through the ipsilateral internal jugular vein. With phlebographic and fluoroscopic control it can be accurately positioned below the renal veins. The procedure is less difficult than some other methods, and does not require major surgical operation. Slow progressive occlusion of the vena cava is supposed to ensue following insertion of the umbrella, but on occasion abrupt occlusion occurs and in some instances clots have been shown to be present on the cardiac side of the umbrella. Erosion out of the vena cava into the ureter or other viscera, or into other vessels has occurred on rare occasions. In most hospitals when the indications for caval interruption arise insertion of the Mobin-Uddin umbrella is considered an extremely useful method, carrying a low morbidity and mortality. Mobin-Uddin has suggested that before the umbrella is placed, ascending contrast phlebography should be done to be certain that the continuing risk of pulmonary emboli is present, because although the procedure is less risky than other major operations, it is attended by a significant number of complications.

Simon, Salzman and Freiman[25] recently reported the development of an innovative technique of inferior vena cava interruption which employs a metal wire that changes shape depending on the temperature to which it is subjected. This experimental filter is made of a nickel-titanium alloy called Nitinol, and exposure to a warm temperature above 32°C causes it to return to a shape previously imprinted. The filter can therefore be introduced into the vena cava via a standard angiographic catheter in the form of a straight wire bathed in a cooling solution. Upon reaching the vena cava the cooling solution is stopped and the wire encounters blood at body temperature, and immediately assumes the shape imprinted at the cool temperature. It then locks itself into position at the desired level of the vena

cava. This filter may prove to be safer than others currently used. It requires less of a surgical procedure than that necessary for the introduction of a Mobin-Uddin umbrella. The preliminary data in the experimental laboratories are extremely encouraging and further testing is in progress.

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Treatment of the Grossly Contaminated Surgical Wound

DR. POLK: If there is any doubt whatsoever, the method of treatment of a wound is by delayed primary closure. I don't think it has ever been improved on as a method for dealing with likely infection. You might use antibiotics in addition, but I think it (primary closure) really is the fail-safe mechanism.

DR. DUNPHY: I think the other message is that if the wound is heavily contaminated, just leave it open. There is an infection rate to the delayed closure . . . The most important thing is not to put a suture through it with the idea that you're going to close the stitch at that time, because that one suture is a potent source of infection introduced at the time of operation. The incidence of infection, when you tighten that, is bound to be high. And I think the same goes for using little wicks. You put a little wick in a wound, or you can put a drain in a wound because you're worried about bleeding, about leak . . . But if you really feel you have a contaminated wound and you put a wick in, . . . it's the surest way to encourage sepsis around it.

—HIRAM C. POLK, JR., MD, *Louisville*
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